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C1Po1C-05: Study on the multiple cooling output characteristics of a gas-coupled high-frequency pulse tube cryocooler

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Gas-coupled type multi-stage high-frequency pulse tube cryocoolers (HPTCs) whose different stages are coupled directly through mass flow offer unique advantages in terms of compact structure and small volume and weight, leading to significant application prospects in special fields such as deep space exploration. However, limited by the subtle intrinsic interaction of gas proportion and energy flow among different stages, few studies have been carried out on the mass-energy transfer mechanism of such cryocooler at cryogenic temperatures below liquid hydrogen, where the cooling capacities can be inevitably small compared to low-frequency cryocoolers. Furthermore, the cooling output is usually feasible only at the cold end of each stage. In order to optimize the refrigeration process of the gas-coupled type HPTCs and to improve the utilization efficiency of the cooling capacities in the higher temperature zone along the cryocooler, a pre-cooling type two-stage gas-coupled HPTC working at liquid-helium temperatures was designed to achieve stepped cooling output. The interstage multiple cooling output characteristics and the intra-stage cooling extraction mechanism were investigated. The research results can provide a useful reference for the practical application of a single HPTC with simultaneous multiple cooling output at different cryogenic temperatures.

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